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ANTHRACNOSE

OF THE

BLACKBERRY AND RASPBERRY

By W. H. LAWRENCE

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ANTHRACNOSE OF THE BLACKBERRY AND RASPBERRY.

By W. H. Lawrence.

For several years the Snyder blackberry, which is grown extensively throughout the Puget Sound country, has not been producing good returns, on account of a greater or lesser per cent of the fruit failing to develop properly, for shipping or canning purposes. At the request of Mr. W. H. Paulhamus, president of the Puyallup and Sumner Fruit Growers' Association, the writer made a study of the trouble. The cause of the trouble and the method of preventing it have been determined. An account of the investigations, with recommendations, are herein given.

THE NATURE AND CAUSE OF ANTHRACNOSE.

This disease, which is commonly known by the popular name of anthracnose, is caused by a very small form of fungus (*Gloeosporium venetum*), consisting of two parts—the mycelium and the spores. The way in which the fungus passes the winter is not known. It probably lives in the canes and fragments of leaves that remain in the field after pruning is done. From field observation on the blackberry, the disease attacks the stems, leaves and fruit during the spring. The spread of the disease is caused by the distribution of the spores. Some of the spores lodge on the host plants. When the climatic conditions are favorable, the spores germinate and form the mycelium, which penetrates the tissue of the stems, leaves and fruit, causing spots on them. The mycelium soon gives rise to a large number of short branches just beneath the thin outer coat (epidermis). Spores are borne on these branches. When they form, they cause the epidermis to break open. These spores are held together by a mucilaginous substance which is soluble in water. In the presence of moisture, the spores are set free and are carried about by the wind and other agents. Some of them are sure to lodge on the various parts of the host plant.

KINDS OF PLANTS ATTACKED.

Among the varieties of blackberries, the Snyder, Kittatany and the Himalaya Giant are attacked. The Lucretia dewberry is also susceptible, while the Logan berry is by no means free from the disease. Of the red raspberries, the Antwerp is injured to a considerable degree, while the Cuthbert is but slightly affected. The Cumberland black raspberry and the Antwerp are equally affected.

Antwerp.—Anthracnose attacks the leaves and stems of this plant. The spots on the leaves are few and small, but not unlike those of the blackberry in general appearance. Those on the canes vary in size from minute dots to more than one sixteenth of an inch in diameter. A majority are well developed. They are much more conspicuous than the spots on the canes of other

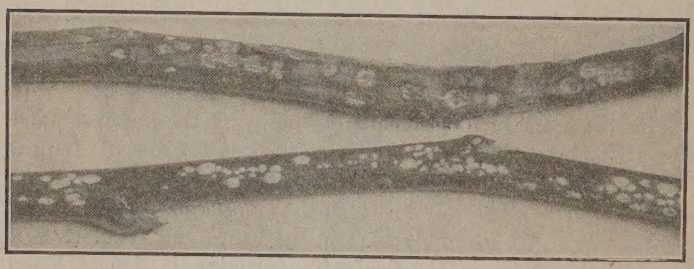

Fig. 1. Spots on the stems of an Antwerp red raspberry, caused by the anthracnose fungus.

plants mentioned. The central portions are light grey to white in color, the margin a reddish brown to almost black in color, while the infested area is shrunken, extending the greater part of the way through the bark. When they are abundant and close enough together so that they merge, large irregular cankers are formed. The disease is more abundant in old fields, in which place it usually does considerable damage.

Cuthbert.—The Cuthbert is only slightly susceptible to the disease. Only a few canes were observed with spots on them. A very few diseased leaves were collected. The spots are not unlike on the leaves and canes of the Antwerp.

Fig. 2. Spots on the stem of the Lawton blackberry, caused by the anthracnose fungus.

Cumberland. — The Cumberland black raspberry in some fields is also badly infested with the disease. It is not unlike the same disease on the Antwerp in its general appearance and effect on the plants.

Snyder.—An examination of the whole plant (a hill), late in the summer, shows that not all parts of it are attacked. No new spots appear on the canes which bear the crop of fruit, or the branches produced during the first season. New ones are more or less abundant on the fruiting laterals which are produced the second season. All the leaves may be infested—those on the lower fruiting laterals and on the main cane and its branches particularly so. The shoots (new canes or current year's growth) are usually well covered with spots from a few inches from the base to a height of three to four feet. The smaller and younger spots are at the upper end. All of the leaves are usually also badly infested. Laterals on the new canes are free from the disease except at the very base. The leaves on these laterals do not become infested.

1. Disease in the Stem.—The spots in the stems are found to be elliptical in shape and have somewhat irregular margins. They vary in size from less to three or four times larger than a pin head—usually about twice as large. The center is a light grey to nearly white in color, while the margin is a deep brown. When these spots are mature in size they are sunken, and oftentimes split open length-

wise with the cane. They usually extend nearly through the bark. When abundant, irregular patches of considerable depth are formed, which act as a partial girdle on the stem.

2. Disease on the Leaves.—The spots in the leaves are round and smaller than those in the canes—usually about half as large as the head of a pin. The centers are nearly white in

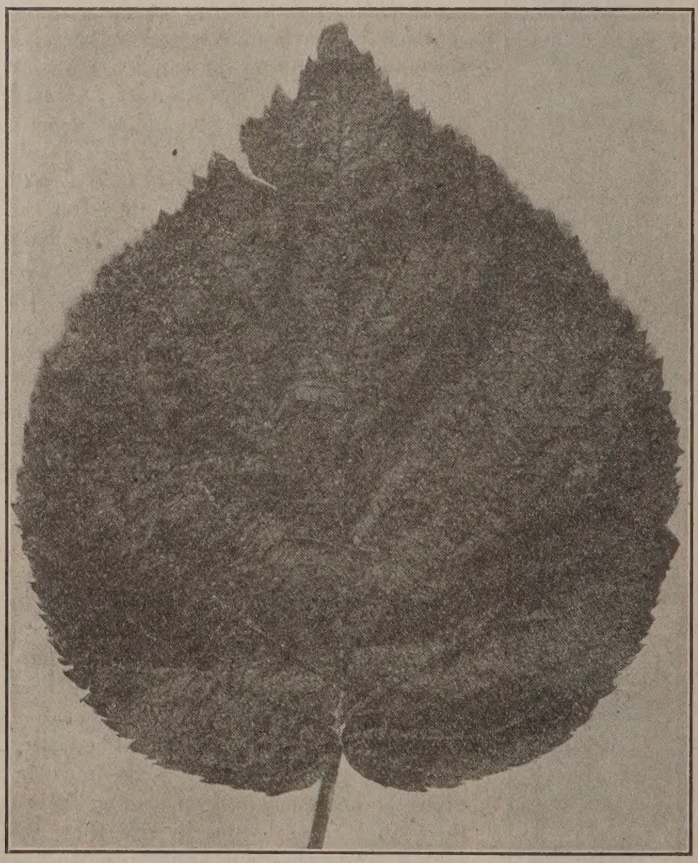

Fig. 3. A leaf of a Snyder blackberry, showing a large number of small spots in the leaf caused by anthracnose fungus.

color, while the borders are wider and of a reddish-brown color. These spots usually extend through the leaf, and when they are abundant run together, forming large patches. These dead areas drop out, leaving holes or slits in the leaves, causing them to appear as if whipped by the wind. The injury done the stem and leaves is very little as compared with the injury done the fruit.

3. Disease on the Fruit.—During the season, the latter part of which is unusually dry on the fruit which is constantly shaded, the disease is most abundant. The upper drupels* of the ber-

Fig. 4. Several Lawton blackberries badly infested with anthracnose. The healthy drupels are plump and smooth, while the diseased ones are dry and badly shriveled.

ries are also more often attacked. The diseased drupels also usually occur in clusters. The disease may attack the fruit at any stage of its development. The greater number become infested while yet green in color and sometimes when no larger than a pea. When the fungus attacks the fruit, it usually finds

*The fruit of the blackberry consists of a short, fleshy branch, bearing numerous small, fleshy fruits growing close together called drupels.

an entrance in the outer end of the drupel, usually near the style of the pistil. There is seldom more than one spot on a drupel. From one to many druples may be infested. Sometimes every drupel on a fruit becomes infested. Evidently on some fruits the infection takes place on nearly all the drupels at the same time, as the spots are all about the same size and equally well developed. On other fruits, the observations made seem to indicate that infection may spread from one drupel to another, since on some badly infested fruits the oldest infested drupels are at the center of the group. This seems to be true only for the more mature fruits. If this is true, the infection comes from spores produced on the drupel and not from the fungus growing from one drupel directly through into another. The fungus matures spores on some of the infested drupels by the time they are about to turn from green to red.

When young drupels become infested, a small brown dot appears on the surface on the end. These areas increase rapidly in size and soon involve the entire surface. In the meantime, the infested portion stops growing, the surface becomes rough and marked with nearly white lines, caused by the epidermis splitting open. As the fruit matures and the amount of water increases in them, the infested areas become more or less shrunken. The spot becomes deeper brown in color. The center of each may become white, owing to the development of masses of spores. At this stage the fruit is nearly red in color, and the spots are very conspicuous. Infested drupels on a well-matured fruit are of a dull reddish brown color. As the drupels mature, the proportion of water in the berry increases very greatly. If infection has taken place early in the season while the drupels are small and do not contain much water, they will remain firm and finally become dry. In case infection takes place when the drupels contain a considerable amount of water, however, they will crush very easily. Fortunately late infection is rather rare, as far as our observations go. A greater number of drupels on ripe fruit are dry enough so that they do not injure the shipping quality of the fruit. When the drupels become infested, the growth is only partially arrested. They continue to grow at the base and partially mature, but do not form a saleable berry.

Kittatany.—The disease attacks the Kittatany the same as described for the Snyder.

Himalaya Giant.—Of the Himalaya Giant the leaves are the only part of the plant that is susceptible. The spots are larger and more conspicuous than on the leaves of the other blackberries.

Lucretia.—The anthracnose on the dewberry (Lucretia) differs somewhat in general appearance and action from the same disease on the blackberry. The fruit very rarely becomes infested, while the disease is very marked on both the leaves and stems. The shoots, as well as the canes, are very badly infested on the stem, from a few inches from the ground to a height of two or three feet. There are few or no spots on the upper

Fig. 5. Spots in the stems of a Lucretia dewberry, caused by anthracnose.

ends of shoots. It is also noticeable that the laterals of young shoots are seldom attacked. When so, the spots are very few in numbers and only grow to be about one-third as large as the spots on the main stem. On the old shoots all the leaves become badly infested, while on the new ones the stalks of the leaves may become well covered with spots, while the blades are entirely or nearly free from them.

The spots on the canes are sometimes so numerous and close together that they merge, forming large irregular patches. As a rule, however, they are well scattered. They are about two or three times as large as a pin head, round or oblong in shape, and somewhat depressed. The dead bark in these spots is nearly white in color and each is surrounded by a reddish-brown ring. Even the very small areas, when viewed closely, show the white center and red ring. These spots on the bright

green stems give the stalk a very conspicuous speckled appearance. On the leaves the spots are even more conspicuous than on the stems. On the more healthy leaves, the young spots are minute and reddish-brown, without a white centre. These older spots are markedly conspicuous on badly infested leaves that have become light yellow in color. This variety of berry plant is injured greatly by the disease.

EXPERIMENTS WITH ANTHRACNOSE.

Inoculation.—Diseased fruit was taken from the field and cultures made of all the bacteria and fungi found growing on it. The forms isolated (with the exception of the form, the spores of which resembled the spore of the fungus causing the disease of the stems and leaves known as anthracnose), grew readily and were soon available for inoculation purposes. The same plans in making the inoculation were followed as described for inoculation with anthracnose, as explained below. Pure culture of these organisms did not produce the disease on the fruit in a single instance.

Owing to the nature of the growth which anthracnose makes in culture media spores cannot be obtained in quantities for inoculation experiments. Cultures of spores from the stems, leaves and fruit, however, produced the same identical growth, showing that the spores are those of the same fungus. Since the culture gave evidence that anthracnose occurs on the fruit, inoculations were made, as described below.

Diseased berries in different stages of maturity, from green to ripe, in which spores of the fungus had not developed, were collected, immersed in fifty per cent alcohol for a few moments, after which they were thoroughly rinsed in sterilized water to remove the alcohol. These berries were then placed in moist chambers. In these cultures, the fungus in the fruit grew from the infested areas in tufted areas and in tufts, arranged in circles around the central portion of the diseased areas, or, in some cases, the rings were continuous, since the tufts were so numerous that they merged. The growth of the fungus in these cases can only be determined by using a lens, since the growth under the naked eye appears very much like a white residue of some salt deposited by the evaporation of water in which it

occurred in solution. The study of the fungus must be brief, since the threads collapse quickly in a dry atmosphere.

On July 20th, short fruiting laterals with apparently healthy berries were placed in water to keep them fresh. Small drops of water were placed on the drupels and spores of the fungus from diseased fruit were placed in them. At the end of fifteen hours some of the drupels, mature enough to turn black in color, showed signs of the disease. Other and younger drupels showed signs of the disease in twenty-four to forty-eight hours. About one-fifth of the inoculations took effect.

On the 26th of July, fruiting laterals from a patch of Snyder blackberries that had not begun to blight were placed in bottles containing water to keep them fresh. Each branch had berries in various stages of maturity from green to ripe. Drops of water were placed on the berries, and spores taken from spots in the leaves and stems of diseased Snyder plants were placed in them. At the end of a week when the fruit had become slightly wilted, numerous spots were found on the fruit in all degrees of maturity. From the general appearance of these spots and their effect on the fruit, it is evident that a majority of the spots on the fruit took effect shortly after the spores were placed in the water.

SPRAYING.

Potassium sulphide (one ounce to 2½ gallons of water), copper acetate (1 ounce to 8 gallons of water), ammoniacal copper carbonate (1 ounce to 16 gallons of water), and Bordeaux mixture were used in the preliminary tests. The object in using the former was to test the value of such sprays as would not leave a residue on the fruit. Poor results were obtained with all sprays except Bordeaux mixture.

How to Prepare the Spray.—Copper sulphate, 4 or 6 pounds; lime, 4 pounds; water, 50 gallons.

Bordeaux mixture is composed of a number of chemical compounds formed when solutions of bluestone and milk of lime are poured together. The chemical changes which take place are delicate, and in order that they take place correctly, the solutions must be diluted, and great care must be exercised in mixing. The method of mixing, as well as using dilute solutions, not only has an important bearing on the chemical, but also on the physical nature of the mixture. The most valuable com-

pound formed, and the one which is easily modified in the mixing, is a bluish, gelatinous substance that has about the same specific gravity as the fluid in which it is suspended. Of the different methods tried, the following has given the best results and is the only recommended:

Bluestone Solution.—To prepare this solution, the bluestone can be dissolved very quickly in a small amount of boiling water. Place the bluestone in a wooden vessel and pour the boiling water over it. Pour the strong solution in a barrel and add enough more cold water to make 25 gallons. The solution may also be prepared by placing the bluestone in a closely woven sack that will not lint, and suspending the same from a stick laid across the top of a barrel, so that the bluestone hangs just beneath the surface of the water in a well-filled barrel. When the bluestone is all dissolved, remove the sack and add enough more water to make 25 gallons of bluestone solution.

Milk of Lime.—To prepare the milk of lime, place 4 pounds of good quicklime (preferably large pieces) in a wooden vessel. Add enough water to wet it thoroughly. When it begins to dry and crumble, add more water. Be careful not to add enough to chill it or too little so that it will burn. When the lime has formed a good paste and is still slaking slowly, allow the slaking to continue and the paste to cool before adding more water. If this method is followed, a smooth paste, free from grit and small lumps of lime will be obtained, provided a good quality of lime has been used. Mix the paste thoroughly with 25 gallons of water.

Mixing.—To mix the solutions of bluestone and milk of lime, two men are required to do the work. Pour the two solutions slowly in such a manner that they mix in falling. If the solutions fall some distance, the churning motion caused by the falling column of water aids in mixing. After the solutions have been poured together, stir the Bordeaux thoroughly, using a wide, wooden paddle. After straining, the mixture is ready for use.

Testing.—The spray should be tested to see if enough lime has been used to unite with all the bluestone. Fill a shallow dish partly full of the Bordeaux mixture and add a few drops of a

solution of ferro cyanide of potash (one ounce to half pint of water). If a reddish-brown color appears, add more lime paste, stir thoroughly and test a second time. Continue to add small amounts of lime paste until the reddish-brown color fails to appear, when the test is made.

Stock Solutions.—When a large quantity of the mixture is needed, mixing is greatly facilitated by preparing stock solutions of both the lime and the bluestone. The best mode of preparing these is to fill a barrel partly full of water and suspend in it 100 pounds of bluestone. When this has dissolved, remove the sack and add enough water to make 50 gallons. You have then a solution in which two pounds of bluestone are dissolved in each gallon of water. Prepare a barrel of milk of lime in the same manner explained for slaking the lime. When this lime solution is stirred thoroughly, each gallon of water contains two pounds of lime. To make 50 gallons of the Bordeaux mixture, measure out three gallons of the bluestone solution and add enough water to make 25 gallons. Measure out two gallons of the milk of lime and add enough water to make 25 gallons. Stir thoroughly, pour the two solutions together, stir, test and strain, following closely the directions given above.

Applying.—In applying the spray, begin at the top of the plants and work downward, giving the canes a thorough coat, and wetting the entire surface of every leaf. Do not use too much spray or it will collect in large drops and run off and much of the value of the application will be lost.

CO-OPERATIVE EXPERIMENTS.*

Spraying experiments were conducted in co-operation with J. P. Gish and J. S. Friedley at Puyallup, and G. J. Anderson, Orton Bros. and W. H. Paulhamus at Sumner. Results have not been as gratifying as was hoped for, but are good enough to encourage the use of Bordeaux on an extensive scale.

Experiments in the Gish Berry Field, 1907.—Four rows of Snyder blackberries, each about 300 feet in length, were sprayed twice with 4-4-50 Bordeaux. The first application was made on May 4th, at which time the plants were nearly in full leaf.

*The writer wishes to acknowledge the assistance and hearty co-operation of Messrs. Gish, Friedley, Clark, Anderson, Orton Bros. and Paulhamus.

The second application was made on May 21st, just before the blossoms opened. Four rows of the same length were left as checks.

During the season, at three separate pickings, the fruit was sorted. This work was personally attended to by Mrs. J. P. Gish.* At the first picking, two crates from sprayed rows gave three-fourths of a box of blighted berries. The same number of boxes from rows that had not been sprayed gave one and one-half boxes of blighted berries. At the second picking there were ninety boxes on each of the sprayed and check portions of the field. Three-fourths of a box was discarded from the sprayed lot and five boxes from the check lot. The third time the fruit was counted, twelve boxes from check hills gave 195 blighted berries, and the same number of boxes from sprayed hills gave only thirty blighted berries. Sprayed portions gave per picking in order named: 1.5, 0.8, 1.0 per cent. blighted fruit. Check rows gave 3.0, 5.5, 8.0 per cent. blighted fruit.

Shortly following the spraying, the foliage of plants grown on sandy loam soil on sprayed rows for a time was a much deeper green than check rows. At picking time this difference was barely noticeable. The beneficial effect of spraying on the leaves was not noticed on plants growing in heavy soil. The fruit, however, on sprayed rows was larger and more glossy. There were among the unsprayed berries many that only had a spot or two of late infection that were not considered blighted but which were detrimental to the general appearance of the fruit. There were a few late infections on the sprayed berries. The blight increased during the season.

Experiments in the Orton Bros.' Berry Field, 1907.—The field of blackberries in which this experiment was conducted consists of Snyder and Kittatany. The greater portion of the plants are of the Snyder variety, with scattering hills of the latter variety. For two years the Kittatany had blighted much worse than the Snyder. In 1906 the field, with the exception of parts of three rows, each eight hills long (rows 7 feet apart, 6 feet apart in the row, hill system) were sprayed twice with 2-3-50 Bordeaux mixture on June 1st and 10th. When the

*Thanks are due Mrs. Gish for her hearty co-operation and the creditable manner in which the data from this experiment were recorded.

berries were gathered, those from rows which were not sprayed showed two to three times more disease than the fruit from sprayed ones.

During 1907 some of the rows were sprayed with 6-4-50 Bordeaux just before the leaf buds opened (last of March to first of April). Later, and just before the flower buds opened (about May 1st) a part of the rows were sprayed a second time with 4-4-50 Bordeaux. During the season no injury from the spray was noticeable, nor was there any beneficial effect on the plants other than the reduction of the amount of disease on stems, leaves and fruit, with the exception that the fruit on rows sprayed twice began to ripen a little earlier in the season.

Twice during the season a portion of the picking was sorted. Twelve boxes were picked from each of a check row, a row sprayed once and a row sprayed twice. The check rows (two) gave an average of 21% blighted fruit, the row sprayed once 7% blighted, and the row sprayed twice 2.5% blighted fruit. About two weeks later, a similar examination and count was made. The check row gave 37% blighted, row sprayed once 16% blighted, and row sprayed twice gave 8% blighted.

These figures show that two sprayings reduced the amount of blight more than two-thirds.

Experiments in the Anderson Berry Field, 1907.—At two dates during the picking season a small amount of the fruit was gathered and sorted from rows that had not been sprayed, rows sprayed once and rows sprayed twice. 4-4-50 Bordeaux was used. The first application was made when the plants were well leafed out and the second about three weeks later, before the blossoms opened. The first sorting of fruit showed 34% blighted fruit on check, 25% on rows sprayed once, and 16% on rows sprayed twice. A second picking a couple of weeks later gave 50% blighted on check, 33% blighted on rows sprayed once, and 20% on rows sprayed twice. These results also show that spraying reduces the per cent. of the disease and that two applications are more valuable than a single spraying.

Experiments in the Gish Berry Field During 1908.—In this experiment, the Snyder blackberry plants sprayed during 1907 were given a single application of 4-4-50 Bordeaux just before the fruit began to turn from red to black. The fruit was sorted

on August 11, 14, 17, 20 and September 1. The per cent. of diseased fruit on sprayed plants decreased from 29% to 12%, with an average of 20%, while the fruit on plants that had not been sprayed gave an average of 39% diseased fruit, varying from 29% to 42%. In the inspection of diseased berries it was also noted that there were three times as many diseased drupels on fruit which had not been sprayed than the fruit which had been coated with Bordeaux mixture. While late spraying reduces the disease, such a practice cannot be recommended, as indicated by the above data.

Experiments in the Paulhamus Berry Field, 1908.—A field of blackberries of the Snyder variety were sprayed twice with 4-4-50 Bordeaux. The first application was made just before the flower buds opened and the second when the fruit was about the size of a field pea. Notes on the condition of the fruit were first taken during the fifth picking on August 15th. An average of twelve boxes of each of sprayed and unsprayed fruit was gathered on August 15, 16, 19, 21, 23 and September 2. After the first picking the per cent. of blighted fruit gradually decreased from 42% to 11%. The average of diseased fruit was 23%. The diseased fruit on plants that had not been sprayed gave an average of 46% diseased fruit. In this fruit there was also a gradual decrease in per cent. of diseased fruit from 61% to 27%.

As indicated by the data, Bordeaux is a valuable preventive against this disease. Again, as has been pointed out above, there was a marked difference in the number of diseased drupels on sprayed and unsprayed fruit. There was a much larger per cent. on the unsprayed fruit.

Experiments in the Friedley-Clark Berry Field, 1908.—A few rows of the Lawton blackberry were sprayed with 4-4-50 Bordeaux, when the fruit began to change from red to black. The berries were inspected on August 10, 14 and 22. The sprayed rows gave 35% diseased fruit, while the unsprayed rows gave 49% diseased fruit. There was an increase of 10% in the disease on unsprayed fruit during the twelve days.

Another field of Lawton berries were sprayed with 4-4-50 Bordeaux. Two applications were made. The first was applied just before the blossoms began to open and the second

just before the fruit began to ripen. The berries were inspected on eight different days from August 3rd to August 23rd, inclusive. There was an average of 29% diseased fruit on the sprayed row and 41% diseased fruit on the checks.

A few hills of Kittatany plants were sprayed twice, in the same manner as described for the Lawton. Three inspections were made (August 3, 10 and 13). Sprayed fruit gave 30% diseased fruit, while the unsprayed gave 40%.

During all these inspections it was to be noted that the number of drupels on diseased fruit from sprayed plants were less numerous than those on diseased fruit from unsprayed plants.

CONCLUSION AND RECOMMENDATIONS.

1. Anthracnose is caused by a small form of fungus.
2. Distribution of the fungus is accomplished by the spores.
3. Anthracnose attacks the Snyder, Kittatany and Himalaya Giant blackberries; the Lucretia dewberry, Logan berry; Antwerp and Cuthbert red raspberries, and the Cumberland black raspberry.
4. The disease is very injurious to the Snyder and Kittatany blackberries, attacking the stems, leaves and fruit.
5. A microscopic study and inoculation experiments show that the same fungus occurs in the spots on stems, leaves and fruit.
6. The fungus attacks the current year's growth of shoots, when they are six inches to one foot in height and later. Spots do not occur on the bases of these shoots.
7. The disease does not spread on the stems and its leaves after the branches form, since the canes and its leaves are infested, while the laterals and their leaves are usually free from the disease.
8. On the Snyder and Kittatany blackberries the fungus spreads from the stems and leaves to the fruit as soon as the young fruit forms.
9. The disease continues to spread on the fruit during the entire season. The fruit is damaged more or less severely, depending on date of infection and the number of drupels on each berry that become diseased.
10. The fungus probably lives over winter in the berry field in the leaves on the ground and in the canes.

11. To check the ravages of the disease destroy the infested leaves and cut out badly diseased canes and shoots before the leaves fall off, and be sure to burn them. In order to kill the spores of the fungus on the canes, spray with 4-4-50 Bordeaux mixture before the leaves appear. In order to protect the leaves and young canes the plants should receive a second application of Bordeaux, when the leaves are well out and by the time the young shoots are six inches in height. A third application should be made just before the blossoms appear.